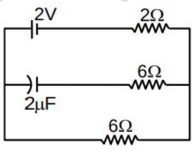
Electrostatic potential and capacitance

CLASS 12 - PHYSICS

Time Allowed: 3 hours **Maximum Marks :** 70

	Section A	
1	A half ring of radius R has a charge per unit length equal toλ . The field at the center is a) zero b) $\frac{2\lambda}{4\pi\varepsilon_0 R}$ c) $\frac{\lambda}{4\pi\varepsilon_0 R}$ d) $\frac{3\lambda}{4\pi\varepsilon_0 R}$	**[1]**
2	Two infinitely long parallel conducting plateshaving surface charge densities$+\sigma$ and $-\sigma$ respectively are separated by a small distance. The medium between the plates is a vacuum. If ε_0 is the dielectric permittivity of vacuum, then the electric field in the region between the plates is a) $\frac{\sigma}{2\varepsilon_0}$ Vm $^{-1}$ b) $\frac{\sigma}{\varepsilon_0}$ Vm $^{-1}$ c) $\frac{2\sigma}{\varepsilon_0}$ Vm $^{-1}$ d) 0 Vm^{-1}	**[1]**
3	An extremely long wire is uniformly charged. An electron is revolving about the wire and making10^8 revolutions per second in an orbit of radius 2 cm. Linear charge density of the wire is nearly: a) $62.5nC/m$ b) $50nC/m$ c) $12.5nC/m$ d) $25nC/m$	**[1]**
4	A charged sphere of radius r has surface charge density. The electric field on its surface is E. If the radius of the sphere is doubled, keeping charge density the same, the ratio of the electric field on the old sphere to that on the new sphere will be: a) $\frac{1}{2}$ b) 1 c) 4 d) $\frac{1}{4}$	**[1]**
5	1. Find the current$i$ supplied by the battery in the network shown in figure in steady state. 2. Find the charge on the capacitor.  a) 0.25 $A, 3\mu C$ b) 0.57 $A, 2\mu C$ c) 1.25 $A, 1\mu C$ d) 0.15 $A, 3.5\mu C$	**[1]**
6	A charge Q is kept at the centre of a circle of radius r. A test charge q_0 is carried from a point X to the point Y on this circle such that arc XY subtends an angle of 60 ^{o} at the centre of the circle. The amount of work done in this process will be	**[1]**

a) $\frac{1}{4\pi\varepsilon_0}\frac{\sqrt{3}Qq_0}{r}$ b) $\frac{1}{4\pi\varepsilon_0}\frac{\sqrt{3}Qq_0}{2r}$

c) Zero d) $\frac{1}{4\pi\varepsilon_0}\frac{Qq_0}{2r}$

7 The work done in carrying a charge Q once round a circle of radius r with charge q at the centre of the circle is **[1]**

a) $\frac{Q\cdot q}{2r}$ b) $\frac{Q\cdot q}{4\pi\varepsilon_0 r}$

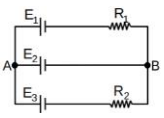
c) zero d) $\frac{1}{4\pi\varepsilon_0}\cdot\frac{Q}{r}$

8 A parallel plate air capacitor has capacity C distance of separation between plates is d and potential difference V is applied between the plates. Force of attraction between the plates of the parallel plate air capacitor is **[1]**

a) $\frac{CV^2}{2d}$ b) $\frac{CV^2}{d}$

c) $\frac{C^2V^2}{2d}$ d) $\frac{C^2V^2}{2d^2}$

9 In the circuit shown here, $E_1 = E_2 = E_3 = 2\ V$ and $R_1 = R_2 = 4\Omega$. The current flowing between points A and B through battery E_2 is: **[1]**



a) $2A$ from B to A b) None of these

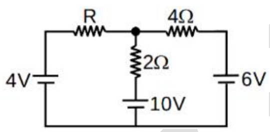
c) 2 A from A to B d) Zero

10 Which can be the unitof Resistivity from the following? **[1]**

a) $\Omega.cm^3$ b) $\Omega.cm^2$

c) $\Omega.m$ d) $V.m$

11 For what value of$R$ in circuit, current through 4Ω resistance is zero? **[1]**



a) 5Ω b) 3Ω

c) 4Ω d) 1Ω

12 Ohm's law is not obeyed by **[1]**

a) All of these b) Discharge tubes

c) Electrolytes d) Vaccum tubes

a) Both A and R are true and R is the correct explanation of A.

b) Both A and R are true but R is not the correct explanation of A.

c) A is true but R is false.

d) A is false but R is true.

13 **Assertion (A):** Some charge is put at the centre of a conducting sphere. It will move to the **[1]**

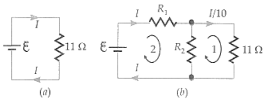
<table>
<tr><td></td><td>surface of the sphere.

Reason (R): Conducting sphere has no free electrons at the centre.</td><td></td></tr>
<tr><td>14</td><td>Assertion (A): The surface of a conductor is always an equipotential surface.

Reason (R): A conductor contains free electrons which can move freely to equalise the potential.</td><td>[1]</td></tr>
<tr><td>15</td><td>Assertion (A): The resistivity of a semiconductor increases with temperature.

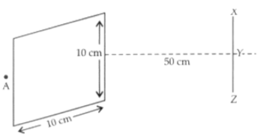
Reason (R): The atoms of a semiconductor vibrate with larger amplitude at higher temperatures thereby increasing its resistivity.</td><td>[1]</td></tr>
<tr><td>16</td><td>Assertion (A): Kirchhoff's voltage law indicates that the electric field is conservative.

Reason (R): Potential difference between two points in a circuit does not depend on the path.</td><td>[1]</td></tr>
<tr><td></td><td>Section B</td><td></td></tr>
<tr><td>17</td><td>A charged spherical conductor has a surface density of 0.7 Cm^{-2} . When its charge is increased by 0.44 C, the charge density changes by 0.14 Cm^{-2} . Find the radius of the sphere and initial charge on it.</td><td>[2]</td></tr>
<tr><td>18</td><td>In the given electrical networks shown in the figures (a) and (b), identical cells each of emfε , are giving same current I. Find the values of the resistors R_1 and R_2 in the network (b).


</td><td>[2]</td></tr>
<tr><td>19</td><td>Distinguish between electric charge and mass.</td><td>[2]</td></tr>
<tr><td>20</td><td>Derive an expression for the electric field at a point on the axis of an electric dipole of dipole moment$\vec{p}$. Also write its expression when the distance r >> the length a of the dipole.</td><td>[2]</td></tr>
<tr><td>21</td><td>Is the momentum conserved when charge crosses a junction in an electric circuit? Why or why not?</td><td>[2]</td></tr>
<tr><td></td><td>Section C</td><td></td></tr>
<tr><td>22</td><td>Given a uniformly charged plane/sheet of surface charge density$\sigma = 2 \times 10^{17}$ C/cm^2 .

1. Find the electric field intensity at a point A, 5 mm away from the sheet on the left side.

2. Given a straight line with three points X, Y and Z placed 50 cm away from the charged sheet on the right side. At which of these points, the field due to the sheet remains the same as that of point A and why?


</td><td>[3]</td></tr>
<tr><td>23</td><td>In the figure given below, find the

1. equivalent capacitance of the network between points A and B.</td><td>[3]</td></tr>
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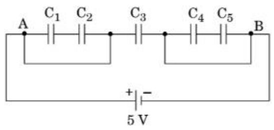
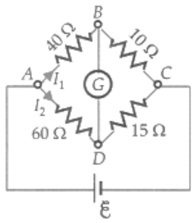
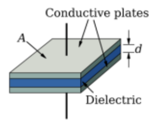
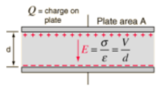
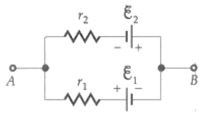
	Given: $C_1 = C_5 = 4\,\mu F$, $C_2 = C_3 = C_4 = 2\,\mu$ F. 2. maximum charge supplied by the battery, and 3. total energy stored in the network. 	
24	1. Write the nature of path of free electrons in a conductor in the a. presence of electric field b. absence of electric field. 2. Between two successive collisions, each free electron acquires a velocity from 0 to v where v =$\frac{eE}{m}\tau$. What is the average velocity of a free electron in the presence of an electric field? Do all electrons have the same average velocity? 3. How does this average velocity of the free electrons, in the presence of an electric field vary with temperature?	[3]
25	Calculate the ratio of the heat produced in the four arms of the Wheatstone bridge shown in Figure. 	[3]
26	1. Two electric field lines cannot cross each other. Also, they cannot form closed loops. Give reasons. 2. A particle of charge 2μ C and mass 1.6 g is moving with a velocity $4\,\hat{\imath}$ ms $^{-1}$. At t = 0 the particle enters in a region having an electric field $\vec{E}$ (in NC $^{-1}$) = $80\,\hat{\imath} + 60\,\hat{\jmath}$. Find the velocity of the particle at t = 5 s.	[3]
27	N drops of mercury of equal radii and possessing equal charges to combine to form a big drop. Compare the charge, capacitance and potential of bigger drop with the corresponding quantities of individual drops.	[3]
28	Define the term 'drift velocity' of electrons in a current carrying conductor and derive, in its term, the expression for current flowing through the conductor.	[3]
	Section D	
	Question No. 29 are based on the given text. Read the text carefully and answer the questions: Capacitanceis the ratio of the change in the electric charge of a system to the corresponding change in its electric potential. Capacitors consist of two parallel conductive plates (usually a metal) which are prevented from touching each other (separated) by an insulating material called the **dielectric** . When a voltage is applied to these plates an electrical current flows charging up one plate with a positive charge with respect to the supply voltage and the other plate with an equal and opposite negative charge.The	[4]

	generalizedequationfor thecapacitanceof a parallel platecapacitoris given as:C = k $\epsilon_0 \frac{A}{d}$ where ε_0 represents the absolute permittivity of the dielectric material being used, and the charge is given by q = CV  	
(i)	When a conductor is placed in an electric field, the field inside the conductor is: - a) negative b) constant c) zero d) positive	
(ii)	The charge on a capacitor is doubled. Its capacity becomes k times wherek: a) k = 2 b) k = 0.5 c) k = 1 d) k = 0	
(iii)	Why does the capacitor block dc signal at a steady - state? a) Due to the high frequency of dc signal b) Due to zero frequency of dc signal c) The capacitor does not pass any current at a steady - state d) Due to the zero frequency of dc signal	
(iv)	What is the value of capacitance of a capacitor which has a voltage of 4V and has 16C of charge? a) 6F b) 4F c) 8F d) 2F	
	Question No. 30 are based on the given text. Read the text carefully and answer the questions: According to Ohm's law, the current flowing through a conductor is directly proportional to the potential difference across the ends of the conductor i.e., I$\propto V \Rightarrow \frac{V}{I}$ = R, where Ris resistance of the conductor. Electrical resistance ofa conductor is the obstruction posed by the conductor to the flow of electric current through it. It depends upon length, area of cross - section, nature of material and temperature of the conductor. We can write, R $\propto \frac{l}{A}$ or R = $\rho \frac{l}{A}$, where ρ is electrical resistivity of the material of the conductor.	**[4]**
(i)	Dimensions of electric resistance is a) [$M^{-1} L^{-2} T^{-1} A$] b) [$ML^2 T^{-3} A^{-2}$] c) [$M^{-1} L^{2} T^{2} A^{-1}$] d) [$ML^2 T^{-2} A^{-2}$]	
(ii)	If 1μ A current flows through a conductor when potential difference of 2 volt is applied across its ends, then the resistance of the conductor is	

	a) $5\times 10^{7}\ \Omega$ b) $1.5\times 10^{5}\ \Omega$ c) $3\times 10^{5}\ \Omega$ d) $2\times 10^{6}\ \Omega$	
(iii)	Specific resistance of a wire depends upon a) none of these b) length c) cross - sectional area d) mass	
(iv)	The slope of the graph between potential difference and current through a conductor is a) curve b) first curve then straight line c) first straight line then curve d) a straight line	
	Section E	
31	A spherical capacitor has an inner sphere of radius 12 cm and an outer sphere of radius 13 cm. The outer sphere is earthed and the inner sphere is given a charge of $2.5\mu C$. The space between the concentric spheres is filled with a liquid of dielectric constant 32. 1. Determine the capacitance of the capacitor. 2. What is the potential of the sphere? 3. Compare the capacitance of this capacitor with that of an isolated sphere of radius 12 cm. Explain why the latter is much smaller.	**[5]**
32	Find the emf (ε_0) and internal resistance (r_0) of a battery which is equivalent to a parallel combination of two batteries of emfs ε_1 and ε_2 and internal resistances r_1 and r_2 respectively, with polarities as shown in the figure. 	**[5]**
33	1. Obtain an expression for the potential energy of an electric dipole placed in a uniform electric field. 2. Three capacitors of capacitance C_1 , C_2 and C_3 are connected in series to a source of Vvolt. Show that the total energy stored in the combination of capacitors is equal to sum of the energy stored in individual capacitors. 3. A capacitor of capacitance Cis connected across a battery. After charging, the battery is disconnected and the separation between the plates is doubled. How will (i) the capacitance of the capacitor, and (ii) the electric field between the plates be affected? Justify your answer.	**[5]**